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None

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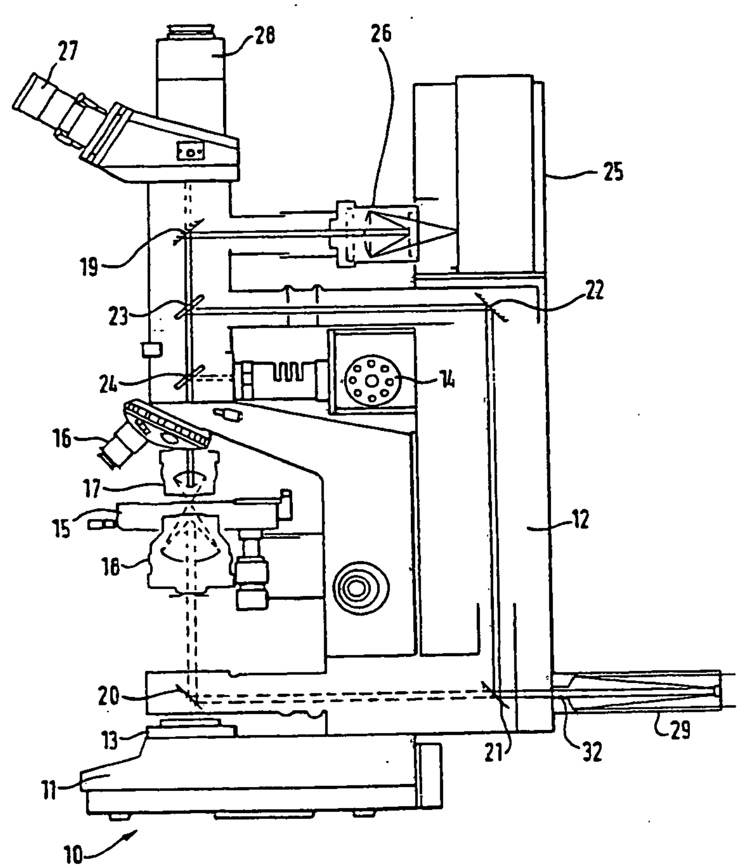
(54) Optical microscope with beam controlling device for coupling to a spectrometer

(57) An optical microscope 10 is combined with a beam controlling device 29 arranged to couple the optical microscope to a spectrometer to receive the external beam of the spectrometer. The high optical throughput and sensitivity of a spectrometer such as a Fourier Transform Infrared Spectrometer is combined with the visual capabilities of an optical microscope. Spectroscopic measurements of transmittance, reflectance and emission can be made.

Fig 1



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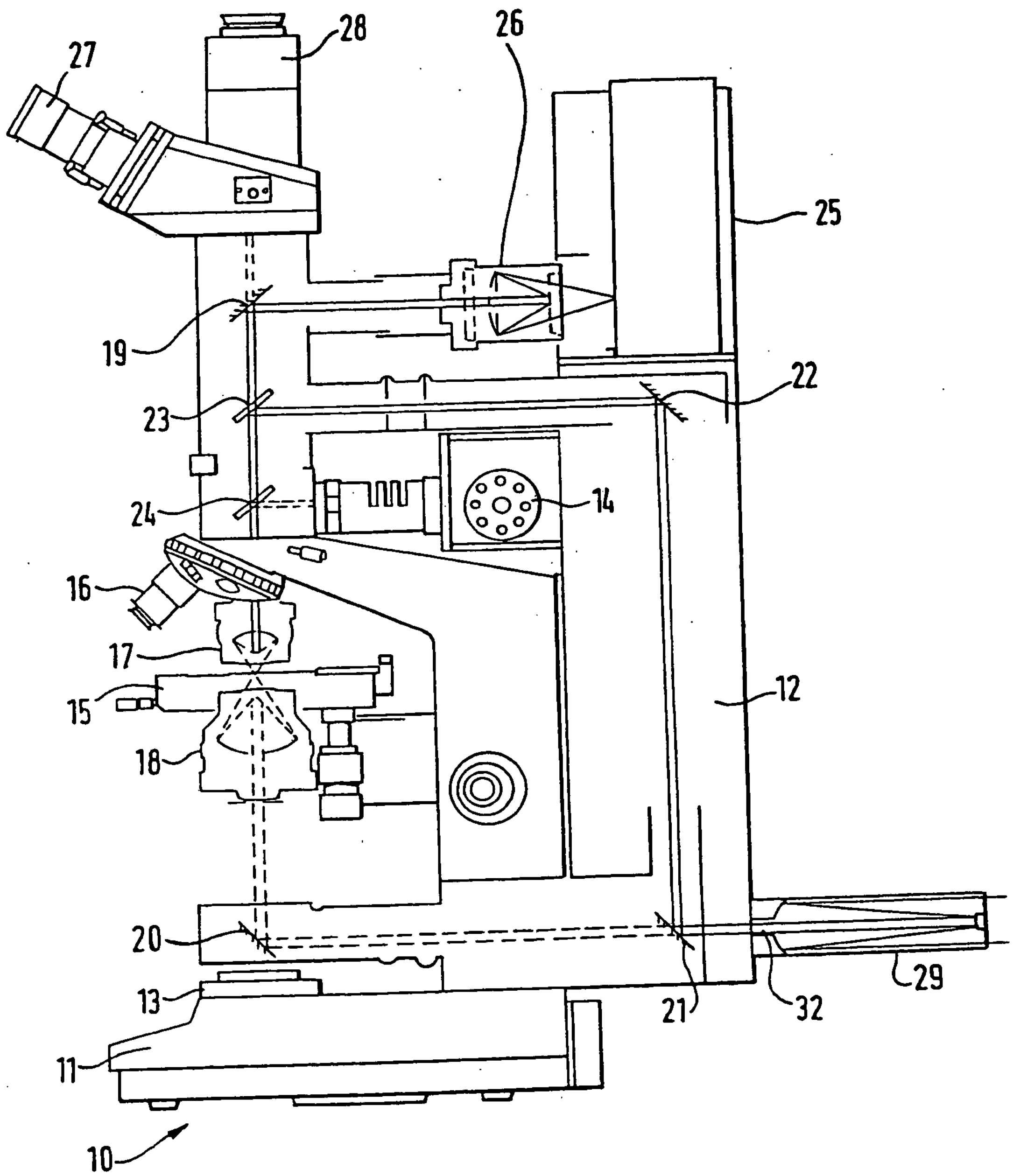
The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

NSDOCID: <GB___2195467A__I_> embodies corrections made under Section 117(1) of the Patents Act 1977.

Fig 1



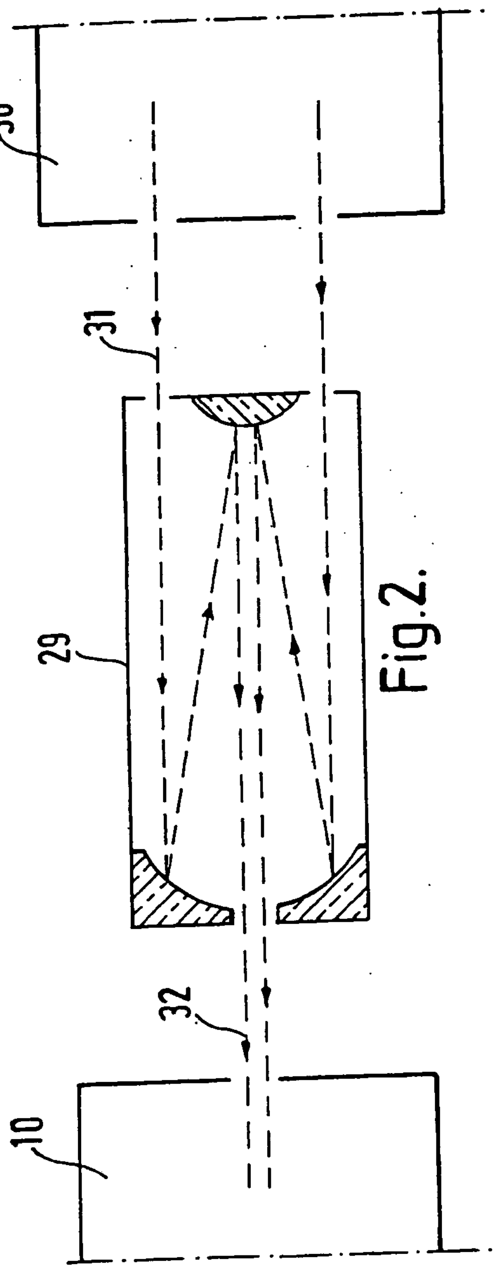


Fig.2.

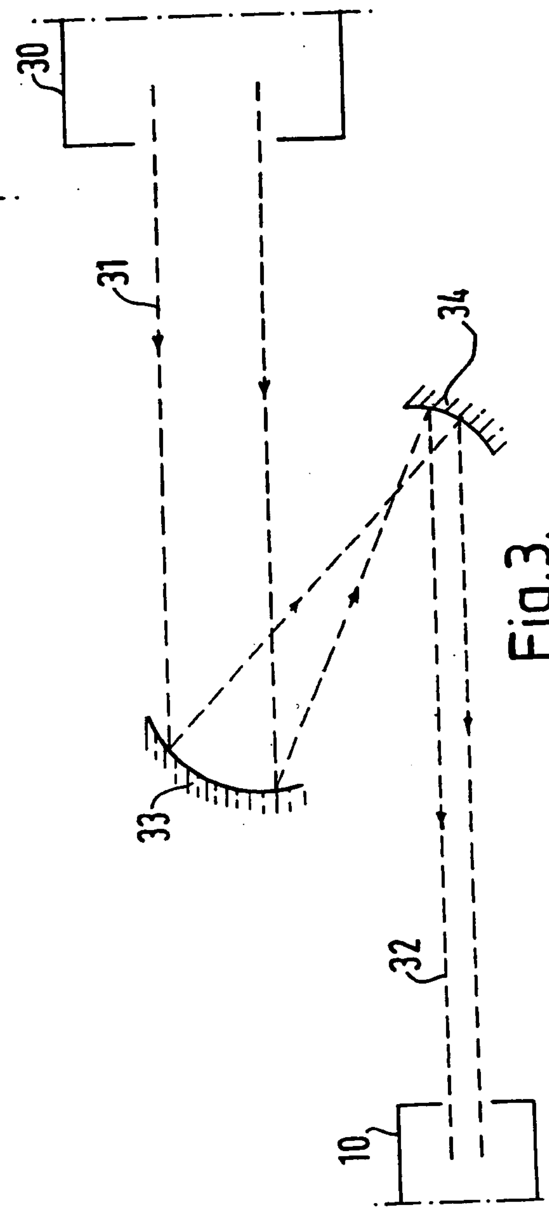


Fig.3.

SPECIFICATION

Improvements relating to microscopes

The invention relates to microscopes.

The invention is concerned with the non-destructive microanalysis of samples of material, for example of fibres or chemicals, using Fourier Transform Infrared Spectroscopy.

In analytical sciences there has always been a need to identify or determine the composition of a small sample or a small area within a larger sample. The classical chemical methods have had limited application and most progress has been made with the techniques of microscopy and spectroscopy. Known techniques include optical microscopy, scanning electron microscopy, electron probe microanalysis, and laser-spectral chemical analysis. These are powerful tools for characterising the sizes, shapes and elemental compositions of samples in the micron size region but the techniques at best only identify the chemical elements involved and do not provide a complete identification.

For complete identification molecular information is required and in recent years, this has been provided by a technique known as Raman spectroscopy and by mass spectrometry. Each of these techniques utilises the spatial resolution of the laser in combination with the sample handling techniques of optical microscopy. Unitl recently similar development of infrared microspectroscopy has been concentrated on dispersive spectrometers using beam condenser accessories which are tedious to use and have poor sensitivity.

The invention provides a further advance in this field.

The invention provides an optical microscope in combination with a beam controlling device arranged to couple the optical microscope to a spectrometer to receive the external beam of the spectrometer.

The beam controlling device may comprise a Cassegrain beam controlling When a beam travels from the spectrometer to the microscope the beam controlling device acts a a beam compressor. When a beam travels in the reverse direction the beam controlling device acts as a beam expander.

Preferably the microscope is for use with a Fourier Transform Infrared Spectrometer.

Preferably the microscope has an optical path at least part of which is utilised by both visible illumination of the microscope and the infrared beam of the spectrometer.

Preferably the microscope includes means to detect the effect of a sample on the infrared beam transmitted by the spectrometer.

Preferably the microscope is capable of transmitting the infrared beam through the sample and reflecting the infrared beam off the sample.

The invention makes it possible to combine the high optical throughput and sensitivity of a Fourier Transf rm Infrared Sp ctr meter with the visual capabilities of an ptical microscope. Spectroscopic measurements of transmittance, reflectance and emission can be made.

The invention includes a method of analysing samples comprising emitting a beam from a spectrometer to a microscope through a beam compressor.

By way of example, specific embodiments of the invention will now be described, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic vertical cross-section through a first embodiment of microscope according to the invention;

Figure 2 is a diagrammatic cross-section showing in more detail the Cassegrain beam compressor of the microscope shown in Figure 1; and

Figure 3 is a view similar to Figure 2 but showing the beam controlling device of a second embodiment of microscope according to the invention.

Turning firstly to Figures 1 and 2, the first embodiment of microscope is illustrated generally by the reference numeral 10 in Figure 1 and has a base 11 from which projects a vertical column 12. The base 11 houses a brightfield illuminator 13 and the column 12 supports a darkfield illuminator 14. Supported on projections from the column are the microscope stage 15 and conventional microscope optics 16, 17 and 18. The microscope is fitted with mirrors 19,20,21 and 22. It is also fitted with two mirror/beam splitters 23 and 24.

The column 12 also supports a detector 25 and associated optics 26. Mounted above the conventional microscope optics 16 are binocular eye-pieces 27 and a closed-circuit television camera 28.

Adjacent to the mirror 21 there is mounted a Cassegrain beam controller 29 which is shown in more detail in Figure 2. In use the beam controller 29 is coupled to a Fourier Transform Infrared Spectrometer 30. It can be seen from Figure 2 how the beam 31 from the spectrometer is reduced in width by the Cassegrain beam controller, acting as a beam compressor thus projecting into the microscope 10 an intense narrow beam 32.

Three modes of operation will now be described.

Transmittance Measurements

A sample to be studied is supported on the horizontal stage 15 which is an X-Y stage. The sample is illuminated by transmitted visible light from the brightfield illuminator 13 in the base 11 of the microscope. In order to view the sample through the ey -pi c s 27 or using the closed circuit television camera 28, mirrors 19 and 20 and beam splitters 23 and

24 ar turned out of the vertical ptical path so that light from the illuminator 13 can pass vertically upwardly straight through the sample to the eye-pieces 27 or camera 28.

Once the area of interest has been located for analysis, spectroscopic analysis can then be carried out by adjusting the optics to transmit the concentrated infrared beam 32 from the spectrometer 30 through the sample and on to the detection device 25. The beam travels horizontally past the mirror 21, strikes the mirror 20 which is now turned into the vertical path, and is reflected vertically upwardly through the sample to the mirror 19, which is also now turned in the vertical path. The beam then travels horizontally from the mirror 19 through the optics 26 to the detection device 25. The optics 26 utilise on-axis Cassegrain all-reflecting mirror objectives to focus the beam. The area of the sample being studied is defined by a variable aperture in the optics 16.

Reflecting Measurements

When using the microscope with samples which are opaque to visible and infrared radiation the area of interest is located by viewing a sample placed on the stage by illuminating the sample with incident visible light directed on to the sample from the darkfield illuminator 14. The mirror/beam splitter 24 is adjusted to reflect the horizontal beam from the illuminator 14 vertically downwardly. Transmitted light from the sample is able to pass vertically through the mirror/beam splitter 24 to reach the eye-pieces 27 or camera 28, the items 19 and 23 being turned out of the optical path.

Once the area of spectroscopic interest has been located, the infrared beam 32 can be directed on to the sample by appropriate positioning of the items 21,22, and 23. The item 24 is now turned out of the path. The reflected infrared beam passes vertically upwardly through the mirror/beam splitter 23 and is reflected by the mirror 19, which is now turned into the path, through the optics 26 to the detection device 25.

Emission Measurements

Infrared emission from a sample can be measured and characterised by supporting the sample on the stage 15 and heating the stage. The infrared emission is then directed back along a reverse path to a detector arranged inside the spectrometer. The path extends vertically from the sample to the mirror/beam splitter 23 which deflects the path horizontally to the mirror 22. The path then travels downwardly from the mirror 22 to the mirror 21 and thence through the beam controller 29, now acting as a beam expander to the spectrometer.

It will be appreciated from the above description that by appropriate use of the re- [illegible] tives of the microscope and the Cassegrain all-reflecting mirror objectiv s, vari- us techniques can be utilised, illustrating the versatility of the invention. It is in fact possible to use darkfield, brightfield and polarised illumination in the reflectance mode and to use brightfield and polarised illumination in she transmittance mode. Variable magnifications may be utilised, and in addition to the use of the binocular eye-pieces 27 and television camera 28, which may be monochrome or colour, photographic recording may also be used.

Real time images in the visible *and* infrared spectral regions may be obtained enabling selective "mapping" experiments to be carried out. The real time images may be made by directing the transmitted or reflected infrared beam from the sample to an infrared sensitive closed-circuit television camera positioned at 28 with a selective infrared filter placed between the mirror 19 and the camera. The mirror 19 is of course turned out of the optical path to allow the beam to pass.

Not only is the microscope very versatile, but the beam compression brought about by the beam compressor 29, combined with the infinity corrected optics of the microscope maximises the optical throughput of the system.

Turning now to Figure 3, there is shown an off axis form of beam controller which enables the microscope to operate in exactly the same way as the microscope shown in Figures 1 and 2. However an off axis beam controller is more versatile. It comprises two concave reflecting mirrors 33 and 34. The mirrors are mounted so that the distance between them may be adjusted, and the mirrors may also be pivoted to adjust their angular relationship. For any given microscope or spectrometer, the position of the mirrors 33 and 34 is adjusted until the beam 31 from the spectrometer 30 is compressed and directed as a parallel beam 32 to the microscope 10.

The device shown in Figure 3 makes it possible to match the microscope 10 to the spectrometer 30, even if the beam 31 emitted by the spectrometer is not exactly parallel.

The invention is not restricted to the details of the foregoing embodiment.

CLAIMS

1. An optical microscope in combination with a beam controlling device arranged to couple the optical microscope to a spectrometer to receive the external beam of the spectrometer.

2. A microscope as claimed in Claim 1, in which the beam controlling device comprises a Cassegrain beam controlling device.

3. A microscope as claimed in Claim 1 or Claim 2, for use with a Fourier Transform Infrared Spectrometer.

4. A microscope as claimed in Claim 3, having an optical path at least part of which is

utilised by both visible illumination of the microscope and the infrared b am of the spectrometer.

5. A microscope as claimed in Claim 3 or Claim 4, which is capable of transmitting the infrared beam through the sample and reflecting the infrared beam off the sample.

6. A microscope constructed and arranged substantially as herein described, with reference to Figures 1 and 2, or Figure 3, of the accompanying drawings.

7. A method of analysing samples comprising emitting a beam from a spectrometer to a microscope through a beam compressor.

8. A method of analysing samples, substantially as herein described, with reference to Figures 1 and 2, or Figure 3, of the accompanying drawings.

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